COLEOPTERA FOUND IN WRACK BEDS AND STRANDLINES AROUND THE KENT COAST

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Abstract

Coleoptera were collected from marine strandlines around Kent by hand searching and extraction sampling. On average, extracting beetles from wrack material (2 litre) by flotation resulted in three times as many specimens as a standard ten minute hand-search. Beetles were most abundant and species-rich during the summer (June–August), although some species were still active in December and January. In total, 402 individuals were collected, belonging to 54 species in 13 families. Most of the species recorded are common in the UK, although many (*e.g. Cercyon littoralis* (Gryllenhal), *Cafius xantholoma* (Gravenhorst) and *Aleochara obscurella* Gravenhorst) are specialized to the strandline habitat. The Nationally Scarce species *Licinus depressus* (Paykull) (Carabidae) and *Aleochara verna* Say (Staphylinidae) were recorded. A specimen of *Myrmecopora oweni* Assing (Staphylinidae) was found at Dungeness and likely represents the first record of this species in Kent. The strandlines found on sandy beaches contained more individuals and species than those on shingle shores, possibly because the wrack on shingle was prone to rapid desiccation. There appeared a geographic split in the composition of the beetle assemblages found on the south and north coasts, primarily because most of the southern sites visited in the survey had shingle beaches and thus low yields of beetles.

Introduction

Wrack beds consist of accumulations of loose seaweed washed up on shore, and can range from substantial masses of material, tens of metres long and metres deep, to the more often seen strandlines or 'wrack strings' (Egglishaw, 1965). When wrack beds are formed beyond the reach of subsequent tides they can remain in place for several days (and even weeks) and are then colonized by a number of arthropod detritivores and their associated predators and parasites. Numerous species of Coleoptera are found in the marine littoral habitat and many occur on these allochthonous deposits of marine debris (Doyen, 1976; Moore & Legner, 1976; Hammond, 2000). Backlund (1945) and Egglishaw (1965) gave lists of Coleoptera found amongst wrack beds in Scandinavia and north-east England respectively and Walsh (1925) described the British coastal beetles associated with seaweed and 'marine rejectamenta' (see also Walsh & Cooter, 2006). Previous ecological studies have examined the temporal patterns in species colonization and the spatial distribution of beetles within large wrack beds (Lavoie, 1985; Inglis, 1989; Phillips & Arthur, 1994; Hodge & Jessop, 1996).

There are sometimes large quantities of non-organic debris and litter within strandlines that are unsightly and dangerous to wildlife, and decomposing wrack beds can be extremely malodorous and have been suspected of producing nuisance 'plagues' of kelp flies (see Oldroyd, 1954). Thus there can sometimes be pressure on civic authorities to remove strandlines from amenity beaches. However, with increased understanding of biodiversity issues there is a realization that strandlines are an important component of coastal ecosystems (Llewellyn & Shackley, 1996; Anon., 1999; Whitehouse, 2005) and can provide a habitat for species of Coleoptera that are considered scarce or nationally rare (e.g. *Nebria complanata* (L.); see also Hodge & Jessop, 1996).

This paper describes a preliminary systematic survey of the beetles associated with wrack beds and strandlines around the coast of Kent. This county, with its proximity to mainland Europe, has an excellent record for containing some of Britain's rarest insect species, including many recent records of coastal Coleoptera new to the UK (e.g. Welch, 1990; Telfer, 2001, 2003). The survey aimed to obtain information on geographical and seasonal patterns in species abundance and compare the beetle assemblages found on sandy beaches with those on shingle shores.

Methods

The survey encompassed ten sites, from Dungeness in the south to Leysdown in the north, following the coastal boundary of East Kent Watsonian Vice-county 15 (Fig. 1). The sites were classified as having either a sandy (Sa), shingle (Sh) or mixed (Mix) beach and each was visited twelve times at approximately monthly intervals between January and December 2004. The sites were: Dungeness (TR094168; Sh), St

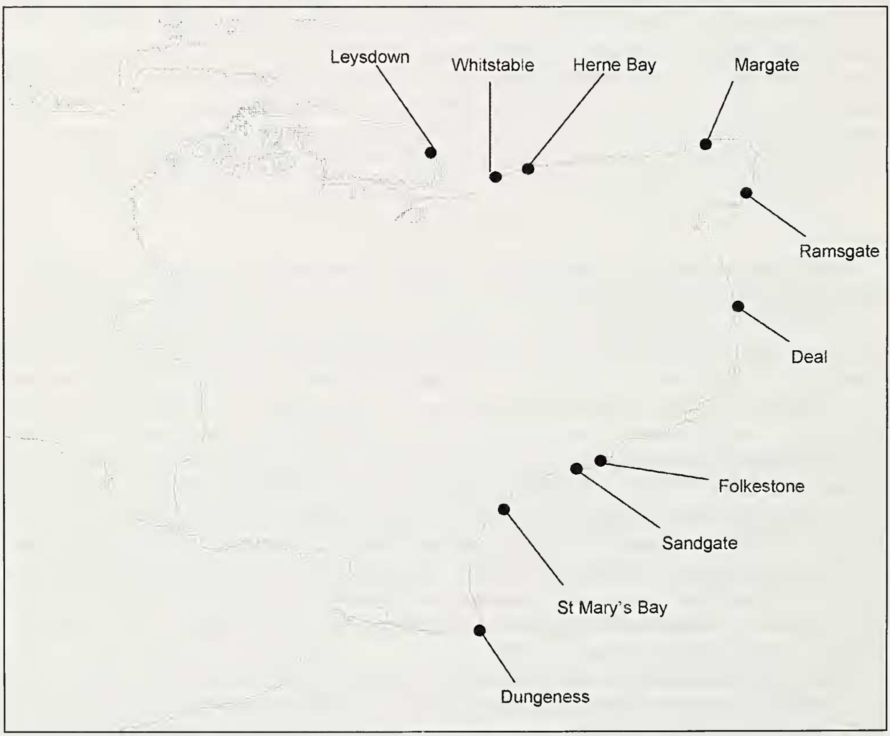

Fig. 1. Map of Kent showing the boundary of Watsonian Vice-county 15 and the locations of the ten sites used in the main survey [outline of map produced using MapMate software Release 2.1.6].

Mary's Bay (TR092275; Mix), Sandgate (TR198350; Sh), Folkestone (TR2326356; Sh), Deal (TR378518; Sh), Ramsgate (TR392655; Sa), Margate (TR349708; Sa), Herne Bay (TR171683; Sh), Whitstable (TR106669; Mix) and Leysdown (TR040701; Mix).

On each sampling visit two collecting methods were used. A standardized ten minute hand search was performed by sorting through the strandline and collecting beetles using a variety of techniques (e.g. glass tubes, forceps, battery-powered aspirators). The second method involved collecting a sample of material (~2 L) from the strandline (and immediate substrate) and returning with it to the laboratory in a plastic bag. Beetles were then extracted from the wrack by first sorting the material over a white tray and then plunging it into water to remove any further specimens by flotation. All specimens were stored in 75% ethanol to which a few drops of glycerol had been added and were determined to species within five months of the final sample being collected (by A.W.). Nomenclature follows that given in the checklists provided by *The Coleopterist* website (as of 7.xii.2006; www.coleopterist.org.uk).

On many occasions no strandline material was present at a site at the time of the sampling visit. When this occurred the beetle counts for both collecting methods were scored as zero.

A further thirteen samples of strandline beetles were collected on a more *ad hoc* basis from locations not used in the main study, or from primary sites on different dates from those of the main survey. The results of these samples are presented in Appendix 1 as they provide records of species not obtained in the main survey and some additional information on geographical distributions.

Results and Discussion

The fauna

A total of 402 beetles was collected in the main survey, comprising 54 species in 13 families (Table 1). Twenty-three of the 54 species were recorded as singletons and nearly half (45%) of the individuals and species were Staphylinidae. The thirteen *ad hoc* samples produced a further 68 individuals belonging to 20 species, six of which were not found in the main survey (see Appendix 1).

Many of the species collected are considered to be closely associated with coastal habitats and marine debris. Of the species recorded here, Walsh & Cooter (2006) list *Anthicus antherinus* (L.), *Cercyon littoralis* (Gyllenhal), *Corticaria crenulata* (Gyllenhal), *Aleochara grisea* Kraatz, *A. obscurella* Gravenhorst, *Atheta triangulum* (Kraatz), *Cafius xantholoma* (Gravenhorst), *Omalium laeviusculum* Gyllenhal, *Omalium riparium* Thomson and *Thinobaena vestita* (Gravenhorst) as being associated with decomposing seaweed. The carabids *Dicheirotrichus gustavii* Crotch and *Paradromius linearis* (Olivier) and the four species of *Bembidion* that were recorded (Table 1; Appendix 1) are also considered to be coastal in their habits, often occurring under tidal debris (Lindroth, 1974; Luff, 1998).

Most of the Staphylinidae collected predate on small insects, mites, dipteran larvae and other invertebrates that live in the wrack, although *Omalium* spp. tend to be mixed feeders, taking in detritus and associated micro-organisms (Hammond, 2000). The carabids recorded were also primarily predators (or scavengers), whilst *Amara familiaris* (Duftschmid) feeds on seeds and vegetable matter and might take some decomposing algal material (Lindroth, 1974; Luff, 2006). The strandline specialists *Cercyon littoralis* and *Cafius xantholoma* prey on dipteran larvae and adult flies, and it has been demonstrated that the latter species can exhibit a close spatial association with its prey within the wrack bed (Phillips & Arthur, 1994). *Aleochara* spp. typically

Table 1. Total numbers of Coleoptera collected from twelve site-visits using hand searching and extraction sampling techniques. [DG – Dungeness; SM – St Mary's Bay; SA – Sandgate; FK – Fokestone; DE – Deal; RA – Ramsgate; MA – Margate; HB – Herne Bay; WH – Whitstable; LN – Leysdown].

		DG	SM	SA	FK	DE	RA	MA	HB	WH	LN	Total
Anthicidae	*Anthicus antherinus* (L.)	–	–	–	–	–	–	–	–	–	3	3
Carabidae	*Amara familiaris* (Duftschmid)	–	3	–	–	–	–	–	–	–	1	4
	Bembidion lunulatum (Fourcroy)	–	–	–	–	–	–	–	–	–	1	1
	Bembidion minimum (Fabr.)	–	–	–	–	–	–	–	–	–	1	1
	Bembidion normannum Dejean	–	–	–	–	–	–	1	–	2	1	4
	Dicheirotrichus gustavii Crotch	–	–	–	–	–	1	–	–	–	–	1
	Notiophilus biguttatus (Fabr.)	–	–	–	–	–	–	–	–	1	–	1
	Paradromius linearis (Olivier)	–	–	–	–	–	–	–	–	–	1	1
	Trechus quadristriatus (Schrank)	–	31	–	–	–	1	4	1	3	–	40
Curculionidae	*Ceutorhynchus obstrictus* (Marsham)	–	–	–	–	5	–	–	–	–	–	5
	Ceutorhynchus pallidactylus (Marsham)	–	–	–	–	–	–	–	4	–	–	4
	Sitona hispidulus (Fabr.)	–	–	–	–	–	–	–	–	1	1	2
	Sitona lineatus (L.)	–	3	2	3	–	1	–	1	–	7	17
Chrysomelidae	*Aphthona euphorbiae* (Schrank)	–	–	–	–	–	4	1	4	1	–	10
	Longitarsus luridus (Scopoli)	1	1	–	–	–	–	1	–	–	–	3
	Oulema melanopus (L.)	–	–	–	–	–	–	–	–	–	1	1
	Phaedon tumidulus (Germar)	–	–	–	–	–	–	–	–	–	1	1
	Phyllotreta undulata Kutschera	–	–	–	–	–	–	–	1	–	1	2
	Phyllotreta nigripes (Fabr.)	–	–	–	–	–	–	–	–	–	1	1
Coccinellidae	*Halyzia sedecimguttata* (L.)	–	–	–	–	–	–	1	–	–	–	1
	Tytthaspis sedecimpunctata (L.)	–	1	–	–	–	–	–	–	–	5	6
Helophoridae	*Helophorus brevipalpis* Bedel	–	–	–	–	–	–	–	–	1	–	1
Heteroceridae	*Heterocerus* sp.	–	–	–	–	–	–	–	–	–	1	1
Histeridae	*Kissister minimus* (Aubé)	–	1	–	–	–	–	–	–	–	–	1
Hydrophilidae	*Cercyon littoralis* (Gyllenhal)	–	–	–	–	–	20	23	3	4	17	67
Latridiidae	*Cartodere nodifer* (Westwood)	–	–	–	–	–	–	–	1	–	–	1
	Cortinicara gibbosa (Herbst)	–	–	–	–	–	–	–	–	–	1	1
	Corticaria crenulata (Gyllenhal)	–	–	–	–	–	–	–	–	–	1	1
Nitidulidae	*Meligethes aeneus* (Fabr.)	–	–	–	–	12	–	1	3	6	10	32
Scarabaeidae	*Aphodius prodromus* (Brahm)	–	–	–	–	–	–	–	–	1	–	1
Staphylinidae	*Aleochara bipustulata* (L.)	–	–	–	–	–	–	2	–	–	9	11
	Aleochara grisea Kraatz	–	–	–	–	–	–	–	–	–	1	1
	Aleochara obscurella Gravenhorst	–	–	–	–	–	4	–	–	–	–	4
	Aleochara punctatella Motschulsky	–	–	–	–	–	–	–	–	–	2	2
	Aleochara verna Say	–	–	–	–	–	–	1	–	–	–	1
	Aloconota gregaria (Erichson)	–	5	–	–	–	–	–	–	–	4	9
	Anotylus sculpturatus (Gravenhorst)	–	3	–	–	–	–	–	–	–	–	3
	Atheta triangulum (Kraatz)	–	3	–	–	–	–	–	–	–	–	3
	Cafius xantholoma (Gravenhorst)	3	1	–	2	–	5	15	1	5	11	43
	Chilomorpha longitarsis (Thomson)	–	1	–	–	–	–	–	–	–	–	1
	Cypha longicornis (Paykull)	–	–	–	–	–	–	–	–	–	1	1
	Dinetrota atramentaria (Gyllenhal)	–	1	–	–	–	–	–	–	–	2	3
	Mocyta clientula (Erichson)	–	–	–	–	–	2	–	–	–	2	4
	Mocyta fungi (Gravenhorst)	–	–	–	–	–	–	1	–	–	–	1
	Myrmecopora oweni Assing	1	–	–	–	–	–	–	–	–	–	1
	Omalium laeviusculum Gyllenhal	–	–	–	–	–	2	2	4	9	4	21
	Omalium riparium Thomson	–	–	–	–	–	–	–	–	1	8	9
	Omalium rivulare (Paykull)	–	1	2	–	–	1	–	–	–	–	4
	Phytosus spinifer Curtis	–	–	–	–	–	42	2	–	–	–	44
	Tachyporus hypnorum (Fabr.)	–	–	–	–	1	–	4	–	–	5	10
	Teropalpus unicolor (Sharp)	–	–	–	–	–	–	–	–	–	3	3
	Thinobaena vestita (Gravenhorst)	–	–	–	–	–	–	1	–	4	–	5
	Xantholinus linearis (Olivier)	–	–	–	–	–	–	1	–	–	1	2
	Xantholinus longiventris Heer	–	1	–	–	–	–	–	–	–	–	1
	Total no. of individuals	5	56	4	5	18	83	61	23	39	108	402
	Total no. of species	3	14	2	2	3	11	16	10	13	31	54

live in decaying animal or plant material and several species are adapted to living on the coast under decomposing seaweed. All of the species recorded here are ectoparasitoids of dipteran pupae and attack a range of kelp flies found in the wrack (especially species of *Coelopa* and *Orygma;* Scott, 1920).

Chrysomelidae and Curculionidae are generally considered to be foliage feeders, yet members of these families were found at all ten sites and 46 specimens belonging to ten species were recorded. A single specimen of the weevil *Sitona lineatus* (L.) was found by Hodge & Jessop (1996) in strandlines at Whitburn on the north east coast of England, and it was supposed the individual had strayed from vegetation on nearby cliffs. However, Backlund (1945) also recorded *S. lineatus* in Scandinavian wrack beds and, in the current study, 20 specimens of this species were recorded in strandlines at nine sites, suggesting that it might regularly utilize this habitat (Table 1; Appendix 1).

Most of the species collected are considered fairly widespread in the UK, although many are localized to coastal habitats. The Nationally Scarce carabid *Licinus depressus* (Paykull) was found on the shingle beach at Shellness on the Isle of Sheppey (Appendix 1: Lindroth, 1974). This species is often associated with chalk or gravel and has previously been recorded from other coastal sites in Kent, primarily on the south coast (Luff, 1998). The staphylinid parasitoid, *Aleochara verna* Say, a species regarded as Nationally Scarce, was found in dry strandlines on the upper shore at Sheerness (Appendix 1) and also at Margate (Table 1). One of the few individuals to be collected from the sporadic strandlines at Dungeness was another staphylinid, *Myrmecopora oweni* Assing [*sensu* Owen (1999), but see Hammond (2000) who raises some uncertainty regarding the taxonomy and nomenclature for *M. oweni* and the closely related *M. brevipes*]. Owen (1999) suggested that *M. oweni* is widespread along the southern coast of Britain but we believe this species has not previously been recorded as far east as Dungeness and this specimen represents the first record of *M. oweni* in Kent (E. Philp, pers. comm.).

Seasonal patterns in beetle abundance

A peak in the number of individuals collected occurred between June and August (Fig. 2). The samples taken in May were very poor in terms of numbers of specimens collected. This was because most beaches did not have any major strandlines when the samples for this month were collected and, due to some hot dry weather, any

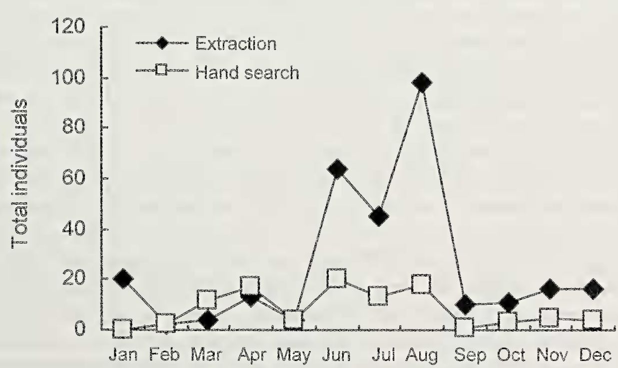

Fig. 2. The total number of Coleoptera collected from strandlines at ten sites in Kent by hand searches and extraction sampling over a 12-month period.

strandline material present was extremely sparse and desiccated. The seasonal patterns in abundance were largely a consequence of the patterns observed for the three most common species. *Cercyon littoralis* and *Cafius xantholoma* were most abundant from June to August and *Phytosus spinifer* Curtis had a clear peak in abundance in the August samples. The drop in numbers in May was common to all three of these species. To augment the summer peaks, 29 specimens of *Meligethes aeneus* (Fabr.) were collected in the July samples and 39 specimens of *Trechus quadristriatus* (Schrank) were found in August.

A number of species were still active in the wrack beds during winter. For example, *Cercyon littoralis*, *Aloconota gregaria* (Erichson), *Atheta triangulum*, *Omalium laeviusculum*, *Omalium rivulare* (Paykull) and *Thinobaena vestita* were all collected in January and/or December.

The influence of shore type on beetle abundance

The catches of beetles were small on the shingle beaches, with an average total catch over 12 months (in the combined hand searching and extraction samples) of only 11 individuals per site (Fig. 3). In comparison, the sites with sandy shores and those containing both sandy and shingle components had average total catches of around 70 individuals (Fig. 3). One factor that might explain some of these differences pertains to the ease of catching beetles. Collecting beetles by hand on the flat and uniformly-coloured surface formed by damp sand was relatively simple compared to catching beetles on uneven shingle, where they often rapidly disappeared down the crevices between the pebbles. However, the difference in numbers between shingle and sandy beaches was also seen in the extraction samples and another, more ecological explanation, concerns the condition of the strandlines occurring on the different classes of substrate. On sandy beaches the compacted damp sand on the underside of the wrack beds appeared to prevent the seaweed desiccating too rapidly and maintained it in a sufficiently moist state for insects to utilize. Conversely the strandlines on shingle beaches, unless substantial amounts of material were present, were prone to rapid desiccation and the material became dry, brittle and generally inhospitable for insects.

Comparison of collecting techniques

At nine of the ten sites the extraction samples produced more individual beetle specimens than the hand searches (Fig. 3). As a consequence of this, most species were obtained in greater numbers by the extraction process than the hand searches, although there were some notable exceptions: seven of the nine specimens of *Aloconota gregaria* (Erichson) were obtained by hand searching, as were all ten specimens of *Tachyporus hypnorum* (Fabr.).

A maximum of 38 specimens was collected in a single (2 L) extraction sample, and 11 specimens in a single ten-minute hand search. However, in 120 site visits, the extraction method obtained a total of only 303 individuals (47 species), the hand searches only 99 (26 species). These low total catches are an unfortunate consequence of the systematic nature of the sampling regime used, in that the majority of samples returned no specimens. This prevalence of zeroes (75% of hand searches and 60% of extraction samples) resulted primarily from there being no tangible strandline material present in nearly half of the 120 sampling visits. For some months (e.g. May, see above) and sites (e.g. Dungeness, Sandgate & Folkestone) there was almost a complete absence of strandline or drift line material at the time of the sampling visits. This highlights a rather obvious point, also made by Duffey (1968), that (in

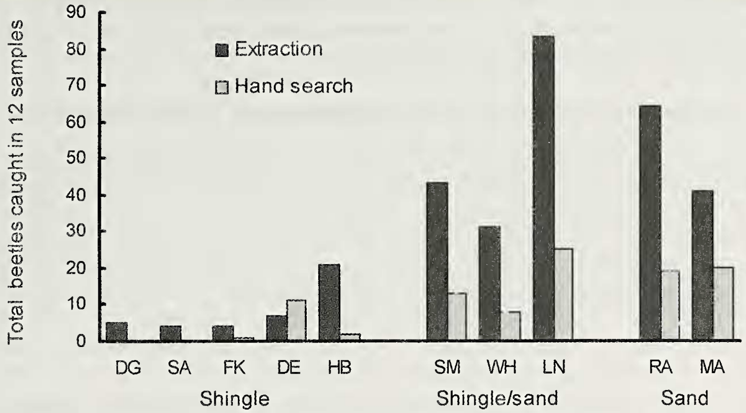

Fig. 3. The total numbers of beetles collected in twelve hand searches and twelve extraction samples taken from the ten primary survey sites. [DG – Dungeness; SM – St Mary's Bay; SA – Sandgate; FK – Fokestone; DE – Deal; RA – Ramsgate; MA – Margate; HB – Herne Bay; WH – Whitstable; LN – Leysdown]

common with other ephemeral insect resources) a site can only possess an easily-defined strandline fauna when this resource is actually present. Even when strandlines did occur, they represented a highly variable resource: if the wrack was too old and desiccated or, conversely, too fresh and recently deposited by the tide, then it was unlikely to contain Coleoptera.

Hand searching might miss some of the smaller species, as dislodging specimens from the wrack can be difficult and small specimens can be difficult to spot against the dark background of decomposing seaweed. Also, the problem of losing specimens among the shingle during hand searching might explain some of the differences observed, although the disparity between techniques also occurred on sandy beaches. An obvious solution to the low numbers found in the hand searches is to extend the duration of the search. However, recent trials have found that even when a sample of wrack has undergone thorough hand searching in the field, beetle specimens can still be extracted from the same material in the laboratory (Hodge, unpub.). Extraction sampling has been used in previous systematic studies of wrack bed insects (Hodge & Jessop, 1996; Hodge & Arthur, 1997) but, in a study of coastal spiders, Duffey (2004) advocated the use of hand searching as it allowed the collector to accurately record the location and niche where each specimen was found. With extraction sampling also, there is a need to look more closely at where the sample of material is obtained from within the wrack bed. This would enable more precise information on where individual beetles are found within the heap and whether they actually occur amongst the wrack material or in the sediment beneath it (Hodge & Jessop, 1996; Hammond, 2000).

Interestingly, in support of Duffey's (2004) findings, although extraction sampling was by far the more successful technique in terms of numbers of beetle specimens obtained, the converse situation occurred for spiders, where twice as many individuals were obtained by hand searching than the extraction technique (Hodge & Vink, 2006). This indicates that any attempt to describe the whole arthropod fauna of wrack beds is likely to require the use of a number of complementary collecting techniques, each more or less appropriate to certain taxa. The setting of pitfall traps in the substrate beneath wrack beds has been utilized with some success (Hodge *et al.*, 1996) and the separation of invertebrates from wrack material by Tullgren funnels has been used to collect smaller species.

Geographical patterns in species distribution and beetle assemblages

Detailed examination of distribution patterns was problematic because the majority of species (76%) were recorded in low numbers ($\leqslant 5$). Of the common species, *Cafius xantholoma* was the most widespread, being recorded at eight of the main sites and was one of only three species found on the sparse strandlines that occurred at Dungeness (Table 1). From the results of the main survey, *Cercyon littoralis* and *Omalium laeviusculum* appeared restricted to strandlines at the five northern-most sites (Ramsgate to Leysdown; Table 1). However, *C. littoralis* was recorded at Dymchurch and Folkestone Warren during the more informal sampling (Appendix 1), indicating that this species is actually more widespread around the county. *Trechus quadristriatus* was widespread but not recorded on any of the purely shingle beaches (Table 1). This preference for sandy beaches was given further support by further specimens being found at Dymchurch and Sheerness in the *ad hoc* samples (Appendix 1).

Of the other common species, 42 of 44 specimens of *Phytosus spinifer* were recorded on the sandy beach at Ramsgate, the remaining pair being found at nearby Margate. However, a single specimen was also recorded on the shingle beach at Lydd on the south coast (see Appendix 1) suggesting this species might also be more widespread than the main survey suggests. The pollen beetle *Meligethes aeneus* (Fabr.) was fairly abundant (32 specimens) and widespread (five sites) although was not found at the south coast sites. Other nitidulids utilize decaying organic resources such as leaf litter, rotting fruit and dung and it seems *M. aeneus* does not find strandlines too inhospitable.

In terms of species found at each site, no two of the assemblages could be considered particularly 'similar', as many species were collected as singletons and only a small proportion (44%) occurred at more than one location (12 species occurred at three or more sites). A cursory examination of the assemblages in Table 1 suggests there might be a split separating the mainly species-poor southern sites (Dungeness to Deal) from those further north. Even though St Mary's Bay had high numbers of specimens and species it still differed from the northern sites because of its high numbers of *Trechus quadristriatus* and absence of the common species *Cercyon littoralis*, *Meligethes aeneus*, *Omalium laeviusculum* (and only a single specimen of *Cafius xantholoma*). The species-poor southern sites (Table 1) all had shingle shores with very sparse and infrequent deposits of wrack material. There is a need to investigate sandy beaches on the south coast, preferably with regular deposits of material (such as those at Greatstone and Folkestone Warren) to try and further separate geographical effects from those of shore type.

Conclusions

This survey represents an initial examination of the beetle assemblages occurring in marine strandlines around the Kent coast. The findings imply there might be differences in the assemblages found on the north and south Kent coasts, and that the assemblages that occur on shingle shores are relatively sparse compared to those on sandy beaches. Not surprisingly, the sites that had high beetle abundance and diversity were those that had a consistent presence of suitable strandlines over the course of the year, such as Leysdown, Ramsgate, Margate and St Mary's Bay.

In total 60 species were recorded, although nearly half were observed as singletons and further sampling is required to establish whether these records represent adventitious individuals or species that occur rarely but consistently in the strandline environment. Taxon accretion curves (Chao estimators; Species Diversity & Richness Software, Pisces Conservation Ltd) based on the total monthly collections suggest strandlines at the ten main sites might possess a total beetle fauna of between 90 - 110 species. In combination with surveying new sites, further species are likely to be found, and more detailed information on species natural histories would be obtained, by considering the different stages of wrack decomposition (Strenzke, 1963; Lavoie, 1985), the horizontal and vertical location within the wrack bed (including the sediment beneath it) (Philips & Arthur, 1994; Hodge & Jessop, 1996; Hammond, 2000) and the species of algae from which the wrack bed is composed.

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References

Anonymous, 1999. *Conservation of Strandlines*. Bangor: Countryside Council for Wales. p 4.

Backlund, H. O. 1945. The wrack fauna of Sweden and Finland. *Opusculum Entomologica Supplementum* **5**: 1–236.

Doyen, J. T. 1976. Marine beetles (Coleoptera excluding Staphylinidae). In: L. Cheng (ed.) *Marine Insects*. Amsterdam, North-Holland Publishing Co. pp 497–519.

Duffey, E. 1968. An ecological analysis of the spider fauna of sand dunes. *Journal of Animal Ecology* **37**: 641–674.

Duffey, E. 2004. The efficiency of timed hand-collecting combined with a habitat classification versus pitfall trapping for studies of sand dune spider faunas. *Newsletter of the British Arachnological Society* **99**: 2–4.

Egglishaw, H. J. 1965. Observations on the fauna of wrack beds. *Transactions of the Society for British Entomology* **16**: 189–216.

Hammond, P. M. 2000. Coastal Staphylinidae (rove beetles) in the British Isles, with special reference to saltmarshes. In: B.R. Sherwood, B.G. Gardiner & T. Harris (eds.) *British Saltmarshes*. pp 247–302.

Hodge, S. & Arthur, W. 1997. Asymmetric interactions between species of seaweed fly. *Journal of Animal Ecology* **66**: 743–754.

Hodge, S. & Jessop, L. 1996. A note on Coleoptera found in wrack beds on the north-east coast of England. *The Coleopterist* **5**: 7–12.

Hodge, S., Jessop, L., Hendy, C. & Patterson, J. 1996. A note on the Diptera and Coleoptera associated with wrack deposits on the island of Raasay. *Scottish Naturalist* **108**: 111–116.

Hodge, S. & Vink, C. 2006. Spiders found on strandlines around the coast of Kent. *Newsletter of the British Arachnological Society* **105**: 3–5.

Inglis, G. 1989. The colonisation and degradation of stranded *Macrocystis pyrifera* (L.) C. Ag. by the macrofauna of a New Zealand sandy beach. *Journal of Experimental Marine Biology and Ecology* **125**: 203–217.

Lavoie, D. R. 1985. Population dynamics and ecology of beach wrack macroinvertebrates of the central California coast. *Bulletin Southern California Academy of Science* **84**: 1–22.

Lindroth, C. H. 1974. *Coleoptera: Carabidae*. Handbooks for the Identification of British Insects Vol. IV, Part 2. London, Royal Entomological Society.

Llewellyn, P. J. & Shackley, S. E., 1996. The effects of mechanical beach-cleaning on invertebrate populations. *British Wildlife* **7**: 147–155.

Luff, M. L. 1998. *Provisional atlas of the ground beetles (Coleoptera: Carabidae) of Britain.* Huntingdon, Biological Records Centre.
Luff, M. L. 2006. Carabidae. In: J. Cooter & M.V.L. Barclay (eds.) *The Coleopterist's Handbook* (4th Edition). Feltham, Amateur Entomologist's Society. pp 18–23.
Moore, I. & Legner, E. F. 1976. Intertidal rove beetles (Coleoptera: Staphylinidae). In: L. Cheng (Ed.) *Marine Insects.* Amsterdam, North-Holland Publishing Co. pp 521–551.
Oldroyd, H. 1954. The seaweed fly nuisance. *Discovery* **15**: 198–202.
Owen, J. A. 1999. The identity of *Myrmecopora brevipes* Butler (Col.: Staphylinidae). *The Entomologist's Record and Journal of Variation* **111**: 275–276.
Phillips, D. S. & Arthur, W. 1994. Observations on the distribution of seaweed fly larvae and other invertebrates within a wrack bed. *The Entomologist* **113**: 154–163.
Scott, H. 1920. Notes on the parasitic staphylinid *Aleochara algarum* Fauv., and its hosts, the phycodromid flies. *Entomologists' Monthly Magazine* **56**: 148–157.
Strenzke, K. 1963. Die Arthropodensukzession im Strandenwurf mariner Algen unter experimentell kontrollierten Bedingungen. *Pedobiologia* **3**: 95–141.
Telfer, M. G. 2001. *Bembidion coeruleum* Serville (Carabidae) new to Britain and other notable carabid records from Dungeness, Kent. *The Coleopterist* **10**: 1–3.
Telfer, M. G. 2003. *Acupalpus maculatus* Schaum, 1860: another carabid new to Britain from Dungeness. *The Coleopterist* **12**: 1–5.
Walsh, G. B. 1925. The coast Coleoptera of the British Isles: a study in insect oecology. *Entomologists' Monthly Magazine* **61**: 137–151.
Walsh, G. B. & Cooter, J. 2006. Collecting-sample habitats. In: J. Cooter & M.V.L. Barclay (eds.) *The Coleopterist's Handbook* (4th Edition). Feltham, Amateur Entomologist's Society. pp 218–239.
Welch, R. C. 1990. *Macrorhyncolus littoralis* (Broun) (Col., Curculionidae), a littoral weevil new to the Palaearctic region, from two sites in Kent. *Entomologists' Monthly Magazine* **126**: 97–101.
Whitehouse, A. 2005. Assessing the importance of strandlines for invertebrate diversity. *Bulletin of the Dipterist's Forum* **60**: 16.

Appendix 1

Records of beetles collected from sites not used in the main study, or from main sites visited on other occasions than that of the main survey. All samples were taken in or under strandline material. [Authorities given only for those species not found in the main survey].

Lydd (TR085208): 25.ix.2004 *Phytosus spinifer*, 1; 3.i.2004 *Cortinicara gibbosa*, 1. Dymchurch (TR100288): 28.viii.2004 *Trechus quadristriatus*, 2; *Cercyon littoralis*, 2; *Cafius xantholoma*, 1. Folkestone Warren (TR243369): 28.iv.2004 *C. littoralis*, 3; *C. xantholoma*, 1; *Teropalpus unicolor*, 2. Broadstairs (TR399680): 30.x.2004 *C. littoralis*, 1; *Monotoma picipes* Herbst, 1; *C. xantholoma*, 1; *Chilomorpha longitarsis*, 1. Margate (TR349708): 3.ix.2004 *C. littoralis*, 3. Whitstable (TR106669): 3.ix.2004 *T. quadristriatus*, 2; *Sitona hispidulus*, 2. Hampton (TR158683): 31.x.2004 *C. littoralis*, 1. Shellness (TR054678): 9.viii.2004 *Bembidion varium* (Olivier), 1; *Licinus depressus* (Paykull), 1 **nb**; *Sitona lineatus*, 1; *C. littoralis*, 6; *Aleochara bipustulata*, 2; *C. xantholoma*, 5; *Megalinus glabratus* (Gravenhorst), 1. Leysdown (TR041701): 9.viii.2004 *C. littoralis*, 1; *Megasternum concinnum* (Marsham), 1; *Acrotona muscorum* (Brisout), 1. Warden (TR024718): 9.viii.2004 *S. lineatus*, 1; *Aphthona euphorbiae*, 1; *C. littoralis*, 7. Minster (TQ956739): 9.viii.2004 *A. bipustulata*, 2. Sheerness (TQ920751): 9.viii.2004 *T. quadristriatus*, 2; *S. lineatus*, 1; *A. bipustulata*, 5; *Aleochara verna*, 2 **nb**; *C. xantholoma*, 1; *Mocyta (Atheta) fungi*,1; *Tachyporus hypnorum*, 1.

nb - Notable